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Minimally invasive lateral, posterior, and posterolateral sacroiliac joint fusion for low back pain: a systematic review and meta-analysis

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Abstract

Objective: This study aimed to evaluate the therapeutic effects of minimally invasive lateral, posterior, and posterolateral sacroiliac joint fusion for low back pain through a meta-analysis.

Methods: The PubMed, Web of Science, Embase, Cochrane Library, and ClinicalTrials.gov databases were comprehensively searched for studies up to 31 August 2024. Relevant studies using lateral, posterior, and posterolateral approaches were identified. Pooled outcomes and publication bias were assessed. The study was registered with PROSPERO (registration No. CRD42023451047)

Results: A total of 48 studies were included: 32 focused on the lateral approach, 10 on the posterior approach, four on the posterolateral approach, and two compared the lateral and posterolateral approaches. The pooled effect analysis showed statistically significant improvements in the visual analog scale (VAS) scores for all three approaches at 6 and 12 months postoperatively. Although no between-approach comparisons were conducted, the pooled improvements in VAS scores at 6 and 12 months postoperatively were numerically similar across all three approaches, as were the pooled fusion rates. The pooled complication rate for the lateral approach was 9.2%, numerically higher than 1% for the posterior approach. The pooled revision rate for the lateral approach was 2.4%, also numerically higher than 0.6% for the posterior approach.

Conclusions: Although pain relief and fusion rates were similar across all approaches, the lateral approach might be associated with a higher risk of total complications and revision surgery.

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Minimally invasive sacroiliac joint fusion, surgical approach, pain relief, total complication rate, revision rate

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Introduction

Low back pain is very common in today's society and often seriously affects patients' quality of life. Some causes of low back pain are related to sacroiliac joint diseases, which need to be confirmed by physical examinations, such as a pelvic compression separation test and Patrick's test.[1] Sacroiliac joint diseases may be treated conservatively and/or surgically. Conservative treatment includes medication, physiotherapy, acupuncture, and local blocking. If conservative treatment is ineffective, sacroiliac joint fusion may be considered.[2–4] Minimally invasive sacroiliac joint fusion has the advantages of less blood loss and a shorter operation time than open fusion,[5] and includes three surgical approaches: lateral, posterior and posterolateral. There are currently few comparative studies of the three surgical approaches in minimally invasive sacroiliac joint fusion, and most meta-analyses have not provided separate analyses for each. The purpose of the present study was to conduct a systematic review and meta-analysis evaluating the therapeutic effects of minimally invasive lateral, posterior, and posterolateral sacroiliac joint fusion on low back pain of sacroiliac joint origin.

Materials and methods

This study followed the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) 2020 guidelines,[6] and was registered on PROSPERO under registration No. CRD42023451047.

Search strategy

The PubMed, Web of Science, Embase, Cochrane Library, and ClinicalTrials.gov databases were searched for articles related to minimally invasive sacroiliac joint fusion for low back pain of sacroiliac joint origin, published up to 31 August 2024. The Medical Subject Heading (MeSH) search terms included sacroiliac joint/surgery and minimally invasive surgical procedures. These keywords and their corresponding free words, together with Boolean operators, were used to create search formulas. The detailed search strategy is provided in Supplemental materials. After removal of duplicates, titles and abstracts were independently screened by two independent reviewers (KX and YLL), with any disagreements resolved by a third reviewer (SHX), followed by full-text review of remaining articles by two independent reviewers (KX and YLL), according to the inclusion and exclusion criteria. In addition, the references of the screened articles were read as an alternative way to identify articles suitable for this meta-analysis. The final selected articles were classified according to the surgical approaches: lateral, posterior, and posterolateral.

Inclusion and exclusion criteria

The inclusion criteria comprised: (1) studies on low back pain of sacroiliac joint origin; (2) studies on minimally invasive sacroiliac joint fusion for low back pain; (3) studies with a follow-up period of more than

6 months; (4) studies published in English; and (5) quantitative studies.

The exclusion criteria comprised: (1) studies including patients with neoplastic disease; (2) studies including patients with acute traumatic diseases; (3) review articles; (4) animal studies; (5) studies with incomplete data; (6) studies on revisional surgery of the sacroiliac joint; (7) studies including patients with infectious diseases; (8) studies with a sample size less than 10; and/or (9) studies with overlapping data.

Assessment of studies

The methodological quality of included studies was assessed independently by two authors (SHX and YLL). Cohort studies, a type of observational study design for evaluating the association between exposure and outcomes, with participants divided into exposed and non-exposed groups, were evaluated for quality using the Newcastle-Ottawa Scale, with a maximum of 9 points.[7] Each cohort study was assessed based on eight items, which were divided into three categories: selection, comparability and outcome. All cohort studies mentioned in the present manuscript were comparative studies, not single-arm studies. The Cochrane Collaboration's tool was used to assess the quality of randomized controlled trials (RCTs),[8] focusing on seven key evaluation criteria, including random sequence generation, allocation concealment, blinding of participants and personnel, blinding of outcome assessment, completeness of outcome data, selective reporting, and identification of potential sources of bias. For case series and prospective multicenter single-arm studies, quality evaluation was conducted using the Joanna Briggs Institute critical appraisal tool,[9] which comprises 10 questions assessing the internal validity and risk of bias. A case series was defined as a descriptive study design that focuses on the characteristics, clinical presentations, treatment responses, and outcomes of patients, without including a control group.

Data extraction

The following data were extracted from the included articles: (1) demographic parameters, including study type, approach, sample size (minimally invasive sacroiliac joint fusion, MISIJF), sex, age, internal implant name, comparison group, follow-up time and prior lumbar fusion proportion; (2) visual analog scale (VAS) score for low back pain preoperatively, and at 6 and 12 months postoperatively; and (3) the total complication rate, revision rate, and fusion rate during the follow-up period. The total complication rate included any intraoperative and postoperative complication. Fusion was defined as bone bridging within the sacroiliac joint and absence of screw loosening on the radiographic image. For both RCTs and cohort studies, only participants who received minimally invasive sacroiliac joint fusion were analyzed. All the parameters were confirmed by two authors (KX and YLL), and in case of disagreement, the two authors negotiated to reach a consensus.

Outcomes

Improvement of VAS score was defined as the mean difference in low back pain scores before and after surgery. The VAS score improvements were calculated at 6 and 12 months postoperatively and pooled estimates for different surgical approaches are presented. Additionally, the pooled total complication rate, pooled revision rate, and pooled fusion rate were calculated and reported for the various surgical techniques.

Certainty of evidence

The Grading of Recommendations Assessment, Development and Evaluation

(GRADE) was used to evaluate the certainty of evidence for the meta-analysis. Using the GRADE approach, the study design was first considered, followed by examination of various factors for potentially downgrading or upgrading the quality of a body of evidence, which was finally classified into one of four levels: very low, low, moderate or high.[10] GRADE was used to assess the quality of evidence for each pooled effect estimate.

Statistical analyses

Meta-analysis, sensitivity analysis and publication bias testing (Egger's test) were performed using Stata 14 (2015) statistical software (StataCorp LLC, College Station, TX, USA). If the number of studies included in the meta-analysis exceeded 10, a publication bias assessment was conducted. Data are presented as mean and SD, with results of individual studies and syntheses displayed utilizing forest plots. When calculating the pooled parameter, P (Q test) <0.1 or $I^2 > 50\%$ was considered to indicate heterogeneity. A leave-one-out sensitivity analysis was conducted to identify potential sources of heterogeneity. Specifically, one study was removed at a time and the meta-analysis was re-run to assess the impact of each study on the overall results. After exploring potential factors contributing to the heterogeneity in the identified study, the study may be excluded. However, caution should be exercised when excluding studies in meta-analyses with a small number of included studies. If no heterogeneity was present, a fixed-effect model was used to combine effect sizes; if heterogeneity existed, a random-effect model was applied.

Results

Search results

A total of 679 articles were identified using the search strategy. After screening and assessing eligible articles, 48 articles were ultimately included in the meta-analysis.[4,5,11–56] The selection process is detailed in Figure 1.

Characteristics of included studies

A total of 32 studies investigated the lateral approach, 10 investigated the posterior approach, four investigated the posterolateral approach, and two compared the lateral and posterolateral approaches (the studies by Claus et al.[11] and Cahueque et al.[12]). The included literature contained three RCTs,[20,25,27] all of which focused on the lateral approach. In two of the RCTs,[20,25] the control group received conservative treatment, and in the RCT by Randers et al.,[27] the control group underwent sham surgery. The remaining study types included six cohort studies,[4,5,11,12,31,33] a total of 33 case series,[13–19,22,23,26,28–30,32,34–37,39,41,42,44,45,47–56] and six prospective multicenter single-arm studies.[21,24,38,40,43,46] All included studies are summarized in Table 1.

Methodological quality of included studies and GRADE assessment

Bias assessments for the case series and prospective multicenter single-arm studies, cohort studies, and RCTs are provided in Supplemental Tables S1, S2, and S3, respectively. Each pooled effect estimate included case series studies, which are considered very low-quality evidence in GRADE assessment, with no potential for upgrading the quality of evidence of case series studies. Therefore, the quality of all pooled effect estimates was rated as very low. Tables summarizing the findings for the lateral approach, posterior approach, and posterolateral approach are provided in Supplemental Tables S4, S5, and S6, respectively.

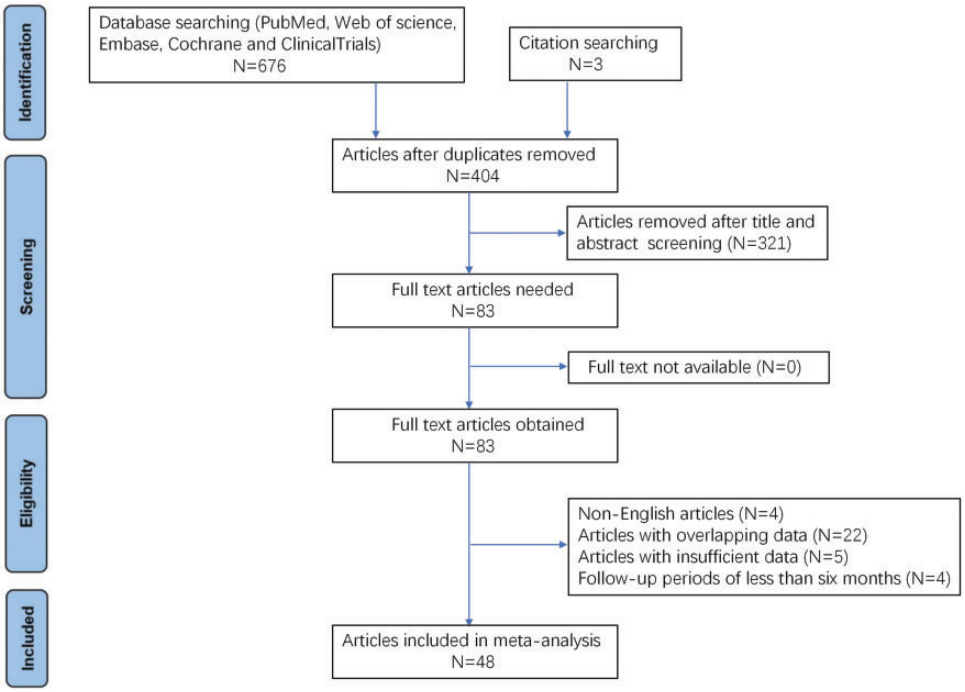

Figure 1. PRISMA flowchart of articles investigating different approaches to minimally invasive sacroiliac joint fusion for low back pain of sacroiliac joint origin included in the meta-analysis.

Outcomes of the meta-analysis

VAS score improvement at 6 months postoperatively. Nine studies on the lateral approach,[11,15,16,21,26,27,36,37,39] three studies on the posterior approach,[43,46,47] and three studies on the posterolateral approach,[11,53,54] reported preoperative and 6-month postoperative VAS scores for low back pain, with pooled mean differences of 4.3 (95% confidence interval [CI] 3.6, 5.0; $I^2 = 92.2\%$, Q test P value <0.001), 4.8 (95% CI 3.6, 6.0; $I^2 = 86.1\%$, Q test P value $= 0.001$), and 3.0 (95% CI 1.6, 4.4; $I^2 = 89.9\%$, Q test P value <0.001), respectively (Figure 2). Following the leave-one-out analysis, no studies were excluded. In these studies, significant pain reduction was consistently observed.

VAS score improvement at 12 months postoperatively. Fifteen studies on the lateral approach,[11,12,15,16,19,21,23,26,28,31,34,36–39] two on the posterior approach,[46,47] and four on the posterolateral approach,[11,12,53,54] reported preoperative and 12-month postoperative VAS scores for low back pain, with pooled mean differences of 5.0 (95% CI 4.5, 5.4; $I^2 = 85.3\%$, Q test P value <0.001), 4.9 (95% CI 3.6, 6.2; $I^2 = 82.5\%$, Q test P value $= 0.017$), and 3.8 (95% CI 1.9, 5.7; $I^2 = 96.5\%$, Q test P value $= 0.001$), respectively (Supplemental Figure S1). Leave-one-out analysis revealed no source of heterogeneity for all approaches. No publication bias was identified in the lateral approach studies.

Significant postoperative reduction in pain was consistently observed in these

Table 1. Characteristics of the 48 articles investigating different approaches to minimally invasive sacroiliac joint fusion for low back pain of sacroiliac joint origin included in the meta-analysis.

First author	Year	Study type	Internal implant name	Approach	Age, years	Sample size, MISIJF	Female, %	Follow-up, months	Comparison group	Prior lumbar fusion, %
Khurana[13]	2009	Case series	HMA	Lateral	NR	15	NR	17	NA	NR
Mason[14]	2013	Case series	HMA	Lateral	57	55	83.6	36.2	NA	NR
Soliman[15]	2022	Case series	iFuse	Lateral	NR	33	73	12	NA	NR
Bornemann[16]	2017	Case series	iFuse	Lateral	54.9	24	91.7	24	NA	NR
Bricard[17]	2024	Case series	iFuse	Lateral	59	54	75.9	24	NA	100
Claus[11]	2020	Cohort study	iFuse	Lateral	55.7	82	73.2	12	Rialto	61.0
Cleveland[18]	2019	Case series	iFuse	Lateral	51	50	76	14	NA	NR
Cummings[19]	2013	Case series	iFuse	Lateral	64	18	67	12	NA	61.1
Dengler[20]	2019	RCT	iFuse	Lateral	49.4	52	73.1	24	CM	NR
Duhon[21]	2016	PMSAS	iFuse	Lateral	50.9	172	69.8	24	NA	44.2
Gaetani[22]	2013	Case series	iFuse	Lateral	53.2	10	100	10	NA	NR
Hermans[23]	2022	Case series	iFuse	Lateral	45.6	29	86.3	12	NA	10.3
Ledonio[5]	2014	Cohort study	iFuse	Lateral	47.9	22	77.3	15	Open surgery	NR
Patel[24]	2021	PMSAS	iFuse	Lateral	53	51	76	24	NA	NR
Polly[25]	2016	RCT	iFuse	Lateral	50.2	102	73.5	6	CM	39.2
Rainov[26]	2019	Case series	iFuse	Lateral	58	160	67.5	12	NA	63.8
Randers[27]	2024	RCT	iFuse	Lateral	45.3	32	91	6	Sham surgery	NR
Rudolf[28]	2014	Case series	iFuse	Lateral	58	17	77	60	NA	47.1
Sachs[29]	2016	Case series	iFuse	Lateral	57.5	107	NR	44.4	NA	36.4
Schmidt[30]	2020	Case series	iFuse	Lateral	50	19	21	58	NA	NR
Vanaclocha[4]	2017	Cohort study	iFuse	Lateral	48	27	70.4	41	CM/denervation	7.4
Smith[31]	2013	Cohort study	iFuse	Lateral	57.4	114	71.9	24	Open surgery	47.4
Kancherla[32]	2017	Case series	iFuse/ Samba	Lateral	52.7	45	68.9	32.6	NA	NR
Cahueque[12]	2023	Cohort study	Sacrix	Lateral	62.9	22	27	12	Posterolateral	59
Agarwal[33]	2024	Cohort study	SI-LOK	Lateral	55	33	78.8	12	iFuse	NR
Chaves[34]	2022	Case series	SI-LOK	Lateral	66	36	61.1	13.3	NA	38.9
Jedi[35]	2023	Case series	SI-LOK	Lateral	32	85	56	6	NA	NR
Mohit[36]	2020	Case series	SI-LOK	Lateral	68.8	44	61.7	24	NA	87.2

(continued)

Table 1. Continued.

First author	Year	Study type	Internal implant name	Approach	Age, years	Sample size, MISIJF	Female, %	Follow-up, months	Comparison group	Prior lumbar fusion, %
Rappoport[37]	2021	Case series	SI-LOK	Lateral	55.2	32	62.5	24	NA	NR
Cross[38]	2018	PMSAS	SImmetry	Lateral	60.1	19	79	24	NA	NR
Kube[39]	2016	Case series	SImmetry	Lateral	47.2	18	56	12	NA	22.2
Kucharzyk[40]	2022	PMSAS	SImmetry	Lateral	60.5	250	70.8	12	NA	36.8
Kasapovic[41]	2022	Case series	Torpedo	Lateral	59	15	66.7	6	NA	NR
Abbasi[42]	2021	Case series	Zyga/Corelink/LnK	Lateral	54	62	NR	12	NA	NR
Davies[43]	2024	PMSAS	Catamaran	Posterior	58.9	33	76	12	NA	18
Endres[44]	2013	Case series	DIANA	Posterior	60.9	19	73.7	13.2	NA	100
Fuchs[45]	2018	Case series	DIANA	Posterior	NR	171	67	24	NA	NR
Calodney[46]	2024	PMSAS	LinQ	Posterior	59	117	70.1	12	NA	NR
Moghim[47]	2024	Case series	LinQ	Posterior	65.5	43	60.4	12	NA	NR
Sayed[48]	2021	Case series	LinQ	Posterior	68	50	52	20	NA	NR
Kaye[49]	2024	Case series	LinQ/PsiF	Posterior	53.4	53	88.7	36	NA	NR
Deer[50]	2021	Case series	LinQ™	Posterior	69.8	111	54.1	9.7	NA	NR
Lynch[51]	2022	Case series	PsiF™	Posterior	63	57	NR	6	NA	NR
Wise[52]	2008	Case series	Threaded cages	Posterior	53.1	13	92.3	29.4	NA	NR
Cross 3rd[53]	2024	Case series	Integrity-SI	Posterolateral	58	75	60	14.2	NA	NR
Anton[54]	2023	Case series	Rialto	Posterolateral	58.6	118	68.6	18.8	NA	50.8
Claus[11]	2020	Cohort study	Rialto	Posterolateral	58.4	74	73	12	iFuse	64.9
Rajpal[55]	2019	Case series	Rialto	Posterolateral	62.2	24	87.5	19	NA	62.5
Cahueque[12]	2023	Cohort study	Sacrix	Posterolateral	62.3	23	48	12	Lateral	52
Raikar[56]	2023	Case series	Sacrix	Posterolateral	61.5	19	89.5	16.2	NA	57.9

NR, not reported; NA, not applicable; RCT, randomized controlled trial; MISIJF, minimally invasive sacroiliac joint fusion; PMSAS, prospective multicenter single-arm study; CM, conservative management.

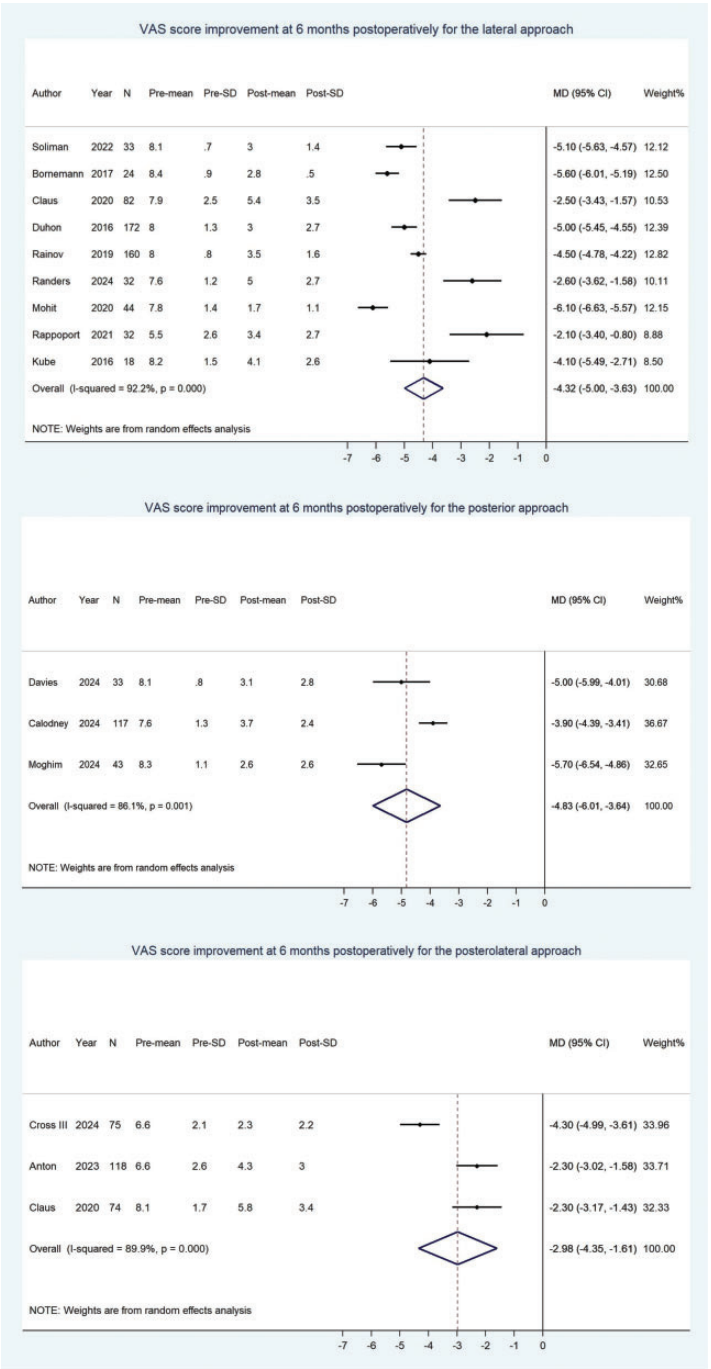

Figure 2. Forest plot of pooled VAS score improvements at 6 months postoperatively for three approaches to minimally invasive sacroiliac joint fusion for low back pain of sacroiliac joint origin. VAS, visual analog scale; N, number; CI, confidence interval; Pre-mean, mean preoperative low back pain; Pre-SD, standard deviation of preoperative low back pain; Post-mean, mean postoperative low back pain; Post-SD, standard deviation of postoperative low back pain; MD, mean difference.

studies. Thus, the impact of preoperative pain scores on VAS score improvement at 12 months postoperatively was analyzed. For studies with preoperative VAS scores $\geq$8, the pooled mean difference in postoperative scores was 5.18 (95% CI 4.72, 5.64), which was numerically higher than that for studies with preoperative VAS scores <8, at 3.94 (95% CI 2.88, 5.00; Supplemental Figure S2).

Total complication rate. Sixteen studies on the lateral approach,[5,12,13,16,18,,20,23,25,27,31,32,35,38–41] six on the posterior approach,[43,46–49,51] and three on the posterolateral approach,[12,55,56] reported total complication rates, with pooled total complication rates of 9.2% (95% CI 4.4%, 15.2%; $I^2 = 83.0\%$, Q test P value <0.001), 1% (95% CI 0.1%, 2.6%; $I^2 = 22.1\%$, Q test P value = 0.267), and 3.7% (95% CI 0.0%, 21.0%; $I^2 = 77.9\%$, Q test P value = 0.011), respectively (Figure 3). Leave-one-out analysis revealed no source of heterogeneity for the lateral and posterolateral approaches. No publication bias was detected in the lateral approach studies.

Revision rate. Twenty-eight studies on the lateral approach,[4,5,11–14,16–21,23–27,29,31–35,37,39–42] seven on the posterior approach,[43,45–48,51,52] and five on the posterolateral approach,[12,53–56] reported revision rates, with pooled revision rates of 2.4% (95% CI 1.3%, 3.9%; $I^2 = 49.6\%$, Q test P value = 0.002), 0.6% (95% CI 0.0%, 1.8%; $I^2 = 42.4\%$, Q test P value = 0.108), and 0.9% (95% CI 0.0%, 2.9%; $I^2 = 0.0\%$, Q test P value = 0.875), respectively (Figure 4). Leave-one-out analysis revealed no source of heterogeneity in the lateral approach. No publication bias was detected in the lateral approach studies.

Analyses of the impact of different implant types on the revision rate for the lateral approach revealed that the pooled revision rate for iFuse implants was 3.3% (95% CI 2.1%, 4.7%), which was numerically higher than that for non-iFuse implants at 1.1% (95% CI 0.2%, 2.4%; Supplemental Figure S3).

Fusion rate. Seven studies on the lateral approach and four studies on the posterolateral approach reported fusion rates,[13,16,26,28,38–40,53–56] with pooled fusion rates of 88.1% (95% CI 76.7%, 96.4%; $I^2 = 83.0\%$, Q test P value <0.001) and 95.2% (95% CI 84.7%, 100.0%; $I^2 = 76.0\%$, Q test P value = 0.006), respectively. Following the leave-one-out analysis, no studies were excluded. The pooled fusion rate for four studies on the posterior approach was 66.9% (95% CI 29.9%, 95.5%; $I^2 = 91.5\%$, Q test P value <0.001).[43–45,52] Through leave-one-out analysis, the study by Fuchs et al.[45] was identified as the source of heterogeneity, with a fusion rate of 31%, significantly lower than other studies, possibly due to suboptimal implant positioning and shorter follow-up duration. After excluding this study, heterogeneity decreased, and the pooled fusion rate was recalculated using a fixed-effects model to be 83.1% (95% CI 69.5%, 93.8%; $I^2 = 0.0\%$, Q test P value = 0.427; Supplemental Figure S4).

Summary of the three approaches

The outcomes of the three surgical approaches are summarized in Table 2.

The pooled complication rate for the lateral approach was 9.2% (95% CI 4.4%, 15.2%), numerically higher than 1% (95% CI 0.1%, 2.6%) for the posterior approach. The pooled revision rate for the lateral approach was 2.4% (95% CI 1.3%, 3.9%), also numerically higher than 0.6% (95% CI 0%, 1.8%) for the posterior approach. The remaining indicators were numerically similar.

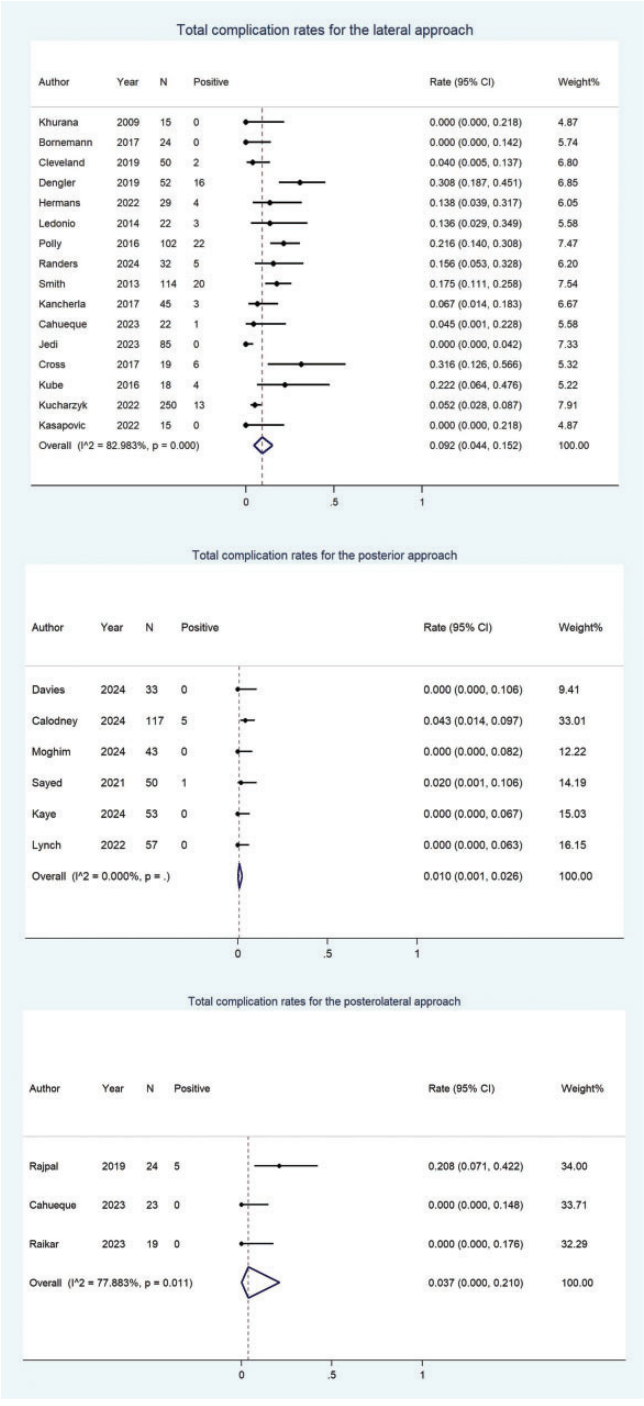

Figure 3. Forest plot of pooled total complication rates for three approaches to minimally invasive sacroiliac joint fusion for low back pain of sacroiliac joint origin. N, number; CI, confidence interval.

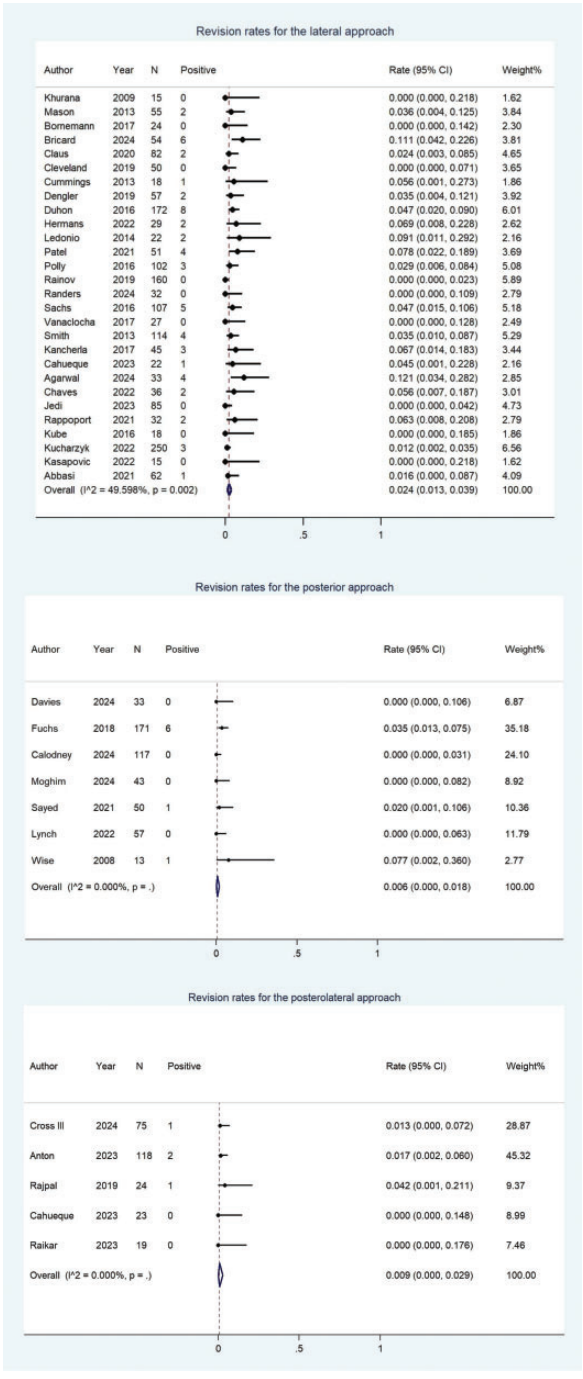

Figure 4. Forest plot of pooled revision rates for three approaches to minimally invasive sacroiliac joint fusion for low back pain of sacroiliac joint origin. N, number; CI, confidence interval.

Table 2. Summary of the therapeutic effects of lateral, posterior, and posterolateral minimally invasive sacroiliac joint fusion techniques for low back pain of sacroiliac joint origin.

	Technique		
Variable	Lateral	Posterior	Posterolateral
VAS score improvement			
6 months postoperatively	4.3 (3.6, 5.0)	4.8 (3.6, 6.0)	3.0 (1.6, 4.4)
12 months postoperatively	5.0 (4.5, 5.4)	4.9 (3.6, 6.2)	3.8 (1.9, 5.7)
Pooled total complication rate, %	9.2 (4.4, 15.2)	1 (0.1, 2.6)	3.7 (0, 21)
Pooled revision rate, %	2.4 (1.3, 3.9)	0.6 (0, 1.8)	0.9 (0, 2.9)
Pooled fusion rate, %	88.1 (76.7, 96.4)	83.1 (69.5, 93.8)	95.2 (84.7, 100.0)

Data presented as mean difference (95% CI) or % (95% CI).
VAS score improvement is defined as the mean difference in low back pain scores before and after surgery.
CI, confidence interval; VAS, visual analog scale.

Discussion

Diagnosing sacroiliac joint-related pain requires imaging studies to exclude other causes of low back pain, such as lumbar spine disorders and peripheral plexopathies. Peripheral plexopathies often affect multiple nerve roots, while lumbar spine disorders typically involve a single nerve root.[57] Currently, there are two ways to achieve sacroiliac joint fusion: minimally invasive surgery and open surgery. According to the literature, minimally invasive sacroiliac joint fusion is generally believed to be superior to open surgery. For example, minimally invasive sacroiliac joint fusion has been associated with less blood loss and a shorter operation time than open fusion, but with similar Oswestry Disability Index.[5] In another study, open sacroiliac joint fusion was associated with greater hospitalization costs than minimally invasive fusion,[58] and minimally invasive sacroiliac joint fusion has been associated with better patient-reported outcomes than open fusion.[59]

To the best of our knowledge, there are very few studies comparing different surgical approaches for minimally invasive sacroiliac joint fusion. Claus et al.[11] reported similar pain relief at 6 and 12 months postoperatively between the lateral approach and the posterolateral approach, which is consistent with the present conclusions.

Cahueque et al.[12] reported a case of nerve compression following lateral approach surgery, requiring revision surgery. However, no such cases were observed with the posterolateral approach, which aligns with the present pooled findings of a higher complication and revision rate with the lateral approach.

In the present study, literature on the treatment of low back pain of sacroiliac joint origin with minimally invasive sacroiliac joint fusion was analyzed. Although pain relief and fusion rates were similar across all approaches, the lateral approach might be associated with a higher risk of total complications and revision surgery.

In 2024, a meta-analysis by Ghaddaf et al.[60] concluded that minimally invasive sacroiliac joint fusion using triangular titanium implants is superior to non-surgical treatments in terms of pain relief, functional improvement, and enhanced quality of life. A review by Mehkri et al.[61] suggested that VAS scores significantly decreased during follow-up after minimally invasive sacroiliac joint fusion, with an average reduction of 50.33% at 6 months postoperatively and 61.94% at 12 months postoperatively. The mean fusion rate was 84.92%.

These findings are similar to those in the present meta-analysis; however, previous meta-analyses have generally not differentiated between the surgical approaches. Of note, the 2023 study by Whang et al.[62] compared pain relief across three different surgical approaches for sacroiliac joint fusion but did not evaluate pain relief at specific time points, whereas the present review included updated studies and pain improvement was calculated at 6 and 12 months postoperatively.

The studies included in the present investigation displayed a wide range of demographic characteristics, with mean ages spanning between 32 and 69.8 years, and the proportions of female patients ranging from 21% to 100% (see Table 1). These demographic factors may have influenced the differences in therapeutic outcomes among the different surgical approaches.

Low back pain may be caused by various conditions located in the lumbar and pelvic regions. Prior lumbar fusion is a common comorbidity, and has been reported in several studies (see Table 1).[4,11,12,17,19,21,23,25,26,28,29,31,34,36,39,40,43,44,54–56] However, the vast majority of studies did not perform subgroup analyses or provide specific data for such analyses, making it impossible to merge this information. The impact of comorbidities on the treatment outcomes of minimally invasive sacroiliac joint fusion warrants further investigation.

At present, there are many studies on minimally invasive sacroiliac joint fusion via the lateral approach, and iFuse is the main implant type. However, there are limited studies involving the posterior and posterolateral approaches. The current meta-analysis indicated that surgery via the posterior approach might offer the advantage of fewer complications. Therefore, minimally invasive sacroiliac joint fusion via the posterior approach has potential for development and deserves additional research.

The results of the present meta-analysis may be limited by several factors: (1) few studies on the posterior and posterolateral approaches were included; (2) most of the studies included in this meta-analysis were case series, providing very low-quality evidence. There were no RCTs on the posterior and posterolateral approach; (3) the search strategy required the inclusion of the terms ‘minimally’ or ‘minimal’ in the title or abstract to ensure a focused selection of studies. However, this approach may have constrained the comprehensiveness of the search, potentially omitting studies that did not use these specific keywords; and (4) through the bias assessment, some articles were found to have a high risk of bias. However, since sensitivity analysis indicated that these high-bias articles were not a source of significant heterogeneity, and the number of studies on the posterior and posterolateral approaches was relatively small, exclusion was considered inappropriate. Therefore, the present findings should be interpreted with caution. More high-quality studies on minimally invasive sacroiliac joint fusion are required in the future to obtain more convincing results.

Conclusions

Pain relief and fusion rates were similar across all approaches to minimally invasive sacroiliac joint fusion for low back pain of sacroiliac joint origin. However, it is important to note that the lateral approach might be associated with a higher risk of total complications and revision surgery.

Author contributions

KX contributed to design, data collection and writing. YLL contributed to data collection and analysis. SHX contributed to data analysis and critical revision. YWP contributed to concept and critical revision. All authors read and approved the final version of the manuscript.

Data availability

The datasets are available from the corresponding author upon reasonable request.

Declaration of conflicting interests

The Authors declare that there are no conflicts of interest.

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Supplemental material

Supplemental tables and figures are provided within the Supplementary materials file, available online.

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